



## Infusing Bioethics into Biology and Microbiology Courses and Curricula: A Vertical Approach

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With the rise of biomedicine and biotechnology, there has been a corresponding growth in the need for better understanding of consequent ethical questions. Increasingly, biologists are being asked not only to offer technical clarifications but also to venture ethical opinions, for which most feel poorly equipped. This expectation puts pressure on biology instructors at the university level to provide biology majors the skills and experience to discuss with some confidence and competence bioethical issues which may arise in either the workplace or through public discourse in everyday contexts. Many fine curricular resources about bioethics are available for varied pedagogical purposes, but few target undergraduate biology or microbiology student audiences. When it occurs in the context of a course, bioethics instruction often is taught by non-biologists outside standard biology curricula. We propose that biologists should strive to “infuse” bioethical thinking into their courses and major curricula but not in such a way as merely to point at ethical problems, treating them at a surface level. We suggest what we call “vertical infusion”: taking one bioethical issue per course and integrating this issue within the context of a relevant biological topic, challenging students to push their thinking beyond their initial intuitions toward underlying scientific and ethical principles. While the vertical approach lacks widespread coverage of ethical issues throughout a single course, it has the advantage of taking the bioethical dimension seriously and in intimate relation to contemporary discoveries in biology and to the biological principles, processes, or procedures that occasioned the ethical quandaries in the first place.

### INTRODUCTION

When biologists teach contemporary or historical discoveries in the life sciences, we often aim not only to impart the facts but also to explore how we know what we know—focusing on the scientific process that led to the revelation of such new scientific information. Many scientist-educators would also like to include in their courses the examination of the future implications of such discoveries, encompassing both the future basic and applied scientific potential as well as the accompanying bioethical dilemmas. Both involve exploring the scientific reaches of new discoveries, but examining bioethical future concerns additionally requires some familiarity with ethical theory and ethical reasoning. In effect, looking forward biologically, we ask “What can we do?” while looking forward ethically we ask “What should we do and why?” To educate our students responsibly, and to introduce bioethics effectively, we should not simply allude to future bioethical challenges—thereby raising awareness—but should also help students to begin developing a

framework for reasoning through those challenges to some resolution about what ought to be done ethically.

Since its emergence as a discipline in the 1970s, bioethics has taken shape as an important academic discipline that intersects with the life sciences in myriad ways, and not only with genetic, biomedical, or biotechnological advances. The UNESCO Universal Declaration on Bioethics and Human Rights (15) established in 2005 has identified 15 principles that range from human dignity, social responsibility, equality, and justice, to protecting the environment, the biosphere, biodiversity, and future generations. However, the integration of clearly reasoned bioethical thinking into undergraduate biology and microbiology curricula has not kept pace with this wide-ranging international awareness and is often limited to research or professional ethics.

During this emergence of bioethics, the traditions of research and professional ethics have evolved with their respective mandates, and have been the default for integrating ethics into undergraduate or graduate courses in the life sciences. *Research ethics* prepares students to perform research ethically, in part by understanding the need to propose research with animals to Institutional Animal Care and Use Committees (IACUCs) or submit research proposed with humans to institutional review boards (IRBs). *Professional ethics* teaches students the

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importance of abiding by professional codes of conduct such as the Code of Ethics for the American Society for Microbiology (<http://www.asm.org/ccLibraryFiles/FILENAME/000000001596/ASMCCodeofEthics05.pdf>). Although research and professional ethics are necessary, they do not adequately address the range of bioethical questions that continue to emerge as the fields of biology and microbiology advance. These questions relate to scientific course content more directly than do policies, regulations, and codes. Indeed, there is some evidence that students appreciate the need for professional ethics but “do not recognize the personal effects of morals and behavior” (6), which is in itself a reason for folding ethics into biology courses.

The challenge of such integration across disciplines is complicated. When women’s studies began in the 1970s a favored pedagogical tactic advised instructors to “add women and stir”—take a traditional course and append a unit that would address women’s issues. Though initially useful, the measure was eventually seen to marginalize the most crucial discussions about women (10). Since those early days, “infusing” women’s issues into the general curriculum has proven an effective tactic, especially when viewed in relation to the original “add women and stir” approach, for infusion tactics require integration of material into the stream of the courses in question, discussing both together, contextualizing and enriching both standard and gender analyses.

In this perspective, we heed that lesson and apply it to the teaching of bioethics in undergraduate science curricula: instead of “adding ethics and stirring,” we suggest “vertical infusion.” That is, instead of inserting ethical issues at several points in each course—necessarily very briefly, and without requiring much depth of thinking—we recommend introducing one ethical topic allied to the professor’s area of expertise or interest and taking the time to work this topic into the science material by means of ethical reasoning. Questions generated by such topics are many and varied. For instance, should we try to clone animals that are on the verge of going extinct even though that extinction is driven by habitat destruction? How do we balance the need to improve agricultural yields with stewardship of the environment? Is feeding fast food/junk food to children in school lunches ethical when we know it can not only negatively affect their health but also potentially the health of subsequent generations? Should there be any limits placed on the genetic information commercially available to individuals? With advances in neuroscience, if pharmaceuticals that enhanced cognition were developed, who could/should take them? Should people, particularly those who are terminally ill, be able to choose the time and means of their own death? What responsibility do we have to maintain the increasingly large pool of embryos developed *in vitro* but which have not been chosen for implantation? Is it ethical to bypass the safety standards for developing safe drugs and vaccines when an epidemic such as Ebola is rapidly expanding?

This vertical infusion approach is also consistent with the reforms currently taking place in undergraduate biology education with more active, student-centered learning, greater interdisciplinary focus and problem-based learning, as detailed in the AAAS Report “Vision and Change in Undergraduate Biology Education: A Call to Action” (1). In this Report of a 2009 national conference designed to develop a blueprint for real change in biology education, the “ability to understand the relationship between science and society” is identified as a core competency in the practice of science with one example being “evaluating ethical implications of biological research” (1).

## VARIOUS APPROACHES TO TEACHING BIOETHICS

Many excellent paths have been proposed to invite students of science disciplines to stretch their reasoning abilities toward the analysis of ethical issues. In 1990, when forming the National Human Genome Research Institute (NHGRI) the National Institutes of Health (NIH) included the ethical, legal, and social implications (ELSI) of the human genome as a significant component of its funded research programs (8). Biology textbooks then began to incorporate ELSI into their auxiliary information, enclosed in textboxes or simply as questions in the margins for those faculty and students who wished to explore these implications further. However, though most often these textbooks dutifully ensure that students get the science right, they do not ask students to reflect more deeply, reasoning with the aid of ethical principles, in order to reach a just resolution of the dilemmas presented.

Another approach is the establishment of science-based bioethics courses within undergraduate biology curricula, as seen at Columbia University in its “Crossroads in Bioethics” and “Bioethics for Biomedical Engineers” courses. In this approach, the scientific issues, ethical challenges and ethical theories appropriate for resolving bioethical challenges are melded into one course (5). Columbia’s integrated bioethics courses have the advantage of giving the students a chance to reason challenging dilemmas through to an ethical conclusion based on both the science and the ethical principles. We also have team-taught such integrated, interdisciplinary courses. One, entitled “Gynebioethics: Reproduction and Beyond,” melded reproductive biology and bioethics, treating, for instance, the genetics of sex determination with the ethics of sex selection. Another course, the “Bioethics of Food,” explored the biological features of the Western diet along with its consequent bioethical entanglements, such as, for example, the duty of a state to outlaw certain substances, such as trans fats, or genetically modified crops. The advantage of such courses is that the science content is more focused, so less competition exists for coverage of that content, leaving more time to actually explore and analyze bioethical issues in depth. However, not all biology programs can afford the faculty resources to develop such integrated approaches.

Still another strategy for including bioethics in the undergraduate biology curriculum could be requiring life science majors to complete an allied bioethics course, as is often the practice for other foundational courses such as chemistry, physics, or math. Although we are not aware of many programs that do so (outside of pre-health studies, such as nursing) one example is the microbiology undergraduate program at Rutgers (<http://dbm.rutgers.edu/microbio.php>) which requires a professional ethics course. We have mentioned the limits of such courses: they canvas professional codes and policies—but not, as a rule, the types of ethical issues that scientists and citizens together may encounter as science advances, such as the possibility of three-parent embryos, the ownership of water rights as sources become scarce, the ethics of transgender fertility, the prospect of cloning beloved pets, or the question of what responsibilities biomedical research institutes have to patients whose tissues are harvested. Yet, even if expanded beyond professional ethical material, such stand-alone bioethics courses are most often taught by philosophers who are not necessarily prepared to integrate the science needed. In cases where this allied course requirement is the approach taken, it would be best to offer bioethics courses team-taught by a scientist and a philosopher to be able to incorporate effectively the science with the ethics. We have offered such team-taught bioethics courses and find students from many backgrounds—biology, philosophy, anthropology, history, psychology, exercise science, and business—fully engaged in the interfaces between science and ethics. Such courses are not required in our biology curriculum at Transylvania University but remain very popular electives.

Both of these kinds of stand-alone courses—the science-based with constant bioethical integration and the team-taught courses with both philosopher and biologist—have definite merits, but they do not address the concerns of biology professors who are committed to challenging their students directly, in the heat of a standard biology or microbiology course. Chamany and colleagues put it this way: “As biology instructors ... we may choose to teach biology devoid of social context, believing that students can make these connections on their own. But students model their instructors’ behaviors, and follow their lead” (4). Given the ever-increasing bioethical concerns attached to practical biological applications, it is not surprising to find many of us wanting to integrate bioethical questions into our own courses—choosing to be the role models Chamany and colleagues discuss. Confident voices of professionally-trained biologists will be needed more urgently as new biotechnologies and other bioscience discoveries emerge, especially in the span of our current students’ careers. If the question is, “What can I do in my own courses to help stimulate mature and considered thinking about ethical aspects of what I teach?” then we recommend infusion of a fairly narrow and well-organized type.

## HORIZONTAL AND VERTICAL APPROACHES TO INFUSION

Biology professors should not apologize for being concerned primarily with scientific content and student ability to understand, apply, and integrate biology principles—appropriately delivered to challenge student problem-solving and analytical thinking skills. When asked what impedes their treatment of ethical issues in their courses, most point to a lack of time (3). Whatever ethical content we examine, it should not interfere significantly with the science being taught but rather complement it and encourage students to see how important good science is to sound ethical reasoning and practice. Even though textbooks use ELSI textboxes and thought-provoking questions to encourage discussion of bioethical issues, instructors may avoid doing so because these novel issues are thought to deflect student concentration at crucial stages of biology instruction. Even if the bioethical prompts are used to raise a number of ethical questions during a term (without going beyond merely showing that an ethical dimension exists), at least two problems ensue as a result. First, such bioethics instruction can be distracting and time-consuming; second, and just as important, since faculty may not want to spend much time on each insertion of bioethical thinking, students could easily get the impression that ethical issues are either too vague and indefinable to contemplate or too unimportant to squander cognitive resources on (11). Complaints like these, especially the latter, contributed to the diminishment of the “add women and stir” approach in women’s studies (10). We call this overall tactic “horizontal” since it spreads bioethical issues thinly across the course. The horizontal approach seems most appropriate for specialized, integrated science-based bioethics courses discussed above, where one is not limited to brief analysis of each bioethical issue, rather than for introductory or advanced biology or microbiology courses in a standard curriculum. See Table 1 for a comparison of vertical and horizontal infusion.

So what do we suggest for professors who responsibly commit to coverage and understanding of the science but also realize the importance of encouraging students to think seriously about ethical issues? We advise what we call a “vertical” approach to teaching the ethical dimension. Instead of trying to invest ethical import wherever it might fit, or, at several convenient points along the progress of the course, the vertical approach focuses on only one issue during the term and only for one occurrence—but that issue is explored in more detail than would be possible if several had to be envisioned. Further, the topic in question could be selected in light of the professor’s research interests, thus making preparation less onerous and more enticing for professor and students alike. If, for instance, one is studying the establishment of the human gut microbiome using 16S rDNA analysis, and the course in question is an introduction to microbiology, then one could expand the normal flora section by discussing biobanking microbes from the human intestinal tract and the subsequent bioethical questions of

TABLE I.  
Comparison of vertical vs. horizontal infusion of bioethics.

Vertical Infusion <sup>1</sup>		Horizontal Infusion <sup>2</sup>	
Pros	Cons	Pros	Cons
Less time required for infusion per course	May require additional training in ethical reasoning or ethical theory for biology faculty	Can get by with fewer faculty having background in ethical reasoning	More time required for infusion per course
Competes less significantly with biological course content	Less breadth of ethical analysis per course	Greater breadth of ethical analysis per course	Competes more significantly with biological course content
Many courses and faculty can address bioethical issues related to their expertise			Few courses and faculty address bioethical issues
Greater depth of bioethical analysis per course			Less depth of ethical analysis per course
Students will get opportunity to analyze deeply and engage fully with a particular issue			Students may get the impression that ethical ideas are vague and difficult to define or resolve

<sup>1</sup>Vertical infusion would involve a single in-depth analysis of a relevant bioethical issue in each or several courses in a biology/microbiology program.

<sup>2</sup>Horizontal infusion would involve introduction of multiple bioethical issues in less depth across a single or a few courses in a biology/microbiology program.

consent, confidentiality, and privacy (see, for instance, the treatment of related ethical issues in Ref. 13, Ch. 5 and 6, especially p 186–204). In this fashion, the question could be addressed more deeply, even to the point of encouraging students to think with the aid of ethical principles, such as the “principlist” ones now common in suggested bioethics curricula, both globally and nationally (5, 9, 12, 14). (Note: we are not advocating for an exclusive focus on principlist ethical theory but suggest that it is a comfortable place to begin.) These basic ethical principles include autonomy/respect for persons, beneficence, non-maleficence, and justice. Their use became more common in 1979 after the release of the Belmont Report from the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research (7) because they are acceptable principles in most cultural and religious traditions. Hence, instead of merely pointing out current policies guiding the just operation of biobanks (professional practice approach), one could ask why these practices are ethical, what principles justify them, and how these principles might radiate out to other similar biomedical practices.

Undergraduate biology and microbiology professors have considerable content to cover, whether in an introductory or advanced course, as we have mentioned. We believe that the horizontal means of infusion of ethics (many examples in one course that are not covered in much depth) can distort the focus of the course, and diminish the importance and urgency of bioethical challenges. Conversely, a vertical approach, where each faculty member might develop a single ethical issue out of their own area of interest, would encourage deeper, more responsible thinking on the part of students—given the parameters of a standard, single-term biology course. With the intense focus comes

a relatively smaller portion of time one needs to allot to integrating ethical concerns. A lab period, or a couple of class periods, especially when devoted to and motivated by one’s own passion, could suffice for deep engagement and productive conversation. Using the example of rights to a person’s microbiome, a professor could explore how students have come to their conclusions about the issue, what ethical principle might lie behind that conclusion, and whether that ethical reasoning might itself be hiding a clash of principles.

Imagine also if a number of faculty members in a department began vertically infusing a single ethical issue in each of their courses. Throughout a student’s major pattern, they would have encountered several ethical issues and been encouraged to give them respectable consideration. On the best construal, each student would be integrating these issues from each course into a coherent style of thinking and critiquing. Any individual student would then have thought about the ethics of GMO foods, stem cells, antibiotic use, preservation of biodiversity, DNA fingerprinting and biobanking, for example, finding similarities and seeking a consistent application of ethical principles. In such a program, students would grow to see their discipline in an even richer dimension and would not be hesitant to engage in the common social discourse about ethical issues related to scientific discoveries.

## CONCLUSION

With the vertical approach, instructors choose their own occasions for infusing bioethical questions, according to their own scientific strengths. How then to help students think clearly about ethical implications that attend



those strengths? As we have mentioned, many excellent resources abound, attached to stand-alone courses and large programs, which might prove valuable, but by and large they are not targeted to aid undergraduate biology faculty who want to infuse a single issue. They are often too narrowly focused on medical ethics or human rights, or they target high school or professional school audiences.

One resource that comes closest we have saved to the last. The NSF-sponsored National Center for Case Study Teaching in Science (<http://sciencecases.lib.buffalo.edu/cs/collection/>) holds in its peer-reviewed collection more than 20 cases related to bioethics that are appropriate for introductory biology courses as well as upper-level ones. However, while well conceived, up to date, accurate with respect to science and technology, and framed with innovative pedagogical suggestions, they nonetheless do not offer help when it comes to actual reasoning about ethical principles. For biology professors using the vertical approach, we would, ideally, suggest that they consult a major classical formulation of principlism found in *The Principles of Biomedical Ethics* by Thomas Beauchamp and James Childress (2). Also, reliable but briefer introductions to those principles are widely available (for instance, Thomas McCormick's at <https://depts.washington.edu/bioethx/tools/princpl.html>). The best way to learn on one's own how to infuse such bioethical principles into one's pedagogy is, as we have suggested, to begin where one is most comfortable, in one's own field, select an ethical issue, and work the principles into one's teaching with that single issue. The best assistance for busy faculty would be for ASM through JMBE or MicrobeLibrary to add a new area to their curriculum resources that focused on resources to support infusing ethics into biology and microbiology curricula. Ideally this would include a variety of resources on different ethical theories that could be applied in science courses, how they could be applied, and possibly additional case studies that demonstrate how to utilize various ethical theories to address bioethical issues. An online course designed by philosophers and biologists together or a summer team-taught workshop (possibly at the ASM Conference for Undergraduate Educators) on infusing bioethics into biology and microbiology courses would be most helpful. These would not be strictly human- or human rights-focused but would include the broad range of ethical issues appropriate for undergraduate biology and microbiology courses from responsible use of antibiotics, biotechnology, and neuroscience to agronomy, physiology, and climate change.

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## REFERENCES

1. **American Association for the Advancement of Science.** 2009. Vision and change in undergraduate biology education: a call to action. AAAS, Washington, DC. p 17.
2. **Beauchamp, T., and J. Childress.** 2013. The principles of biomedical ethics, 7<sup>th</sup> edition, Oxford University Press, Oxford, UK. Part II, chapters 3–6.
3. **Booth, J. M., and J. M. Garrett.** 2004. Instructors' practices in and attitudes toward teaching ethics in the genetics classroom. *Genetics* **168**:1111–1117.
4. **Chamany, K., D. Allen, and K. Tanner.** 2008. Making biology learning relevant to students: integrating people, history, and context into biology education. *CBE Life Sci. Educ.* **7**:276–278.
5. **Loike J. D., B. S. Rush, A. Schweber, and R. L. Fischbach.** 2013. Lessons learned from undergraduate students in designing a science-based course in bioethics. *CBE Life Sci. Educ.* **12**:701–710.
6. **Lysaght, T., P. J. Rosenberger III, and I. Kerridge.** 2006. Australian undergraduate biotechnology student attitudes towards the teaching of ethics. *Int. J. Sci. Educ.* **28**:1225.
7. **National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research.** 1979. The Belmont Report. United States Health and Human Services, Washington, DC. [Online.] <http://www.hhs.gov/ohrp/policy/belmont.html>.
8. **National Human Genome Research Institute.** 1990. ELSI Research Program. [Online.] <http://www.genome.gov/10001618>.
9. **National Institutes of Health.** 2009. Curriculum supplement series, exploring bioethics. [Online.] <https://science.education.nih.gov/customers.nsf/HSBioethics.htm>.
10. **Noddings, N.** 2001. The care tradition: beyond "Add women and stir." *Theory Pract.* **40**:29–32.
11. **Pearce, R. S.** 2009. A compulsory bioethics module for a large final year undergraduate class. *Biosci. Educ.* **13**:1–21. [Online.] <http://journals.heacademy.ac.uk/doi/pdf/10.3108/beej.13.1>.
12. **Presidential Commission for the study of bioethical issues.** 2009. Education. [Online.] <http://bioethics.gov/education>.
13. **Rhodes, R., N. Gligorov, and A. P. Schwab.** 2013. The human microbiome: ethical, legal and social concerns. Oxford University Press, New York, NY.
14. **United Nations Educational, Scientific and Cultural Organization.** 2008. Bioethics core curriculum. [Online.] <http://www.unesco.org/new/en/social-and-human-sciences/themes/bioethics/ethics-education-programme/>.
15. **United Nations Educational, Scientific and Cultural Organization.** 2005. Universal declaration on bioethics and human rights. [Online.] <http://unesdoc.unesco.org/images/0014/001461/146180e.pdf>.